VisuAlea, Towards a Scientific Modelling Environment using Visual Programming

Christophe Pradal, Daniel Barbeau, Thomas Cokelaer, Eric Moscardi

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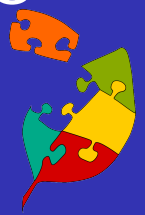

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OpenAlea Goals

OpenAlea is an open source platform for modelling plant development and functionning at different scales.

Sharing knowledge

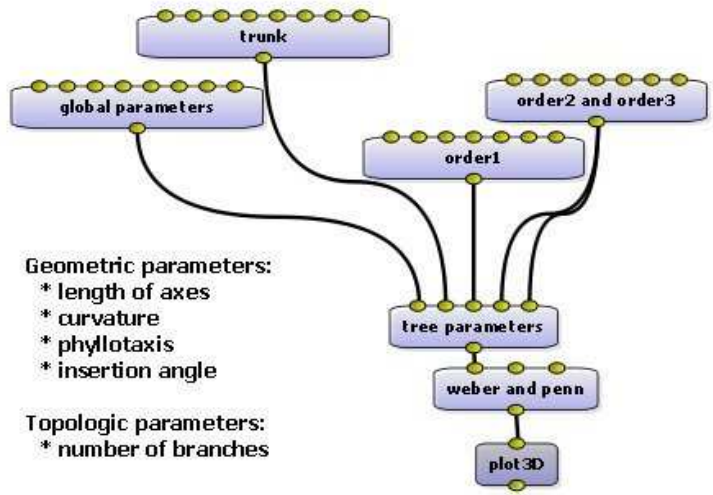
- Reuse software and tools
- Share development between various labs
- Share databases and training efforts

Common software platform

- Integration of existing software & tools
- Rapid development of new models
- Enhance accessibility
- Quality rules

Design choices

- Open Source scientific community
  - Distributed development (sprints)
- Language centric (Python)
  - Common modelling language
  - Glue language
- Component architecture
  - Dynamic composition
  - High-level dataflow approach
- Visual programming (**VisuAlea**)
  - Graphical model representation
  - Automatic GUI generation
- Shared deployment tools
  - Build, packaging, installation, distribution, update



Visual Programming

Visual Programming Environments

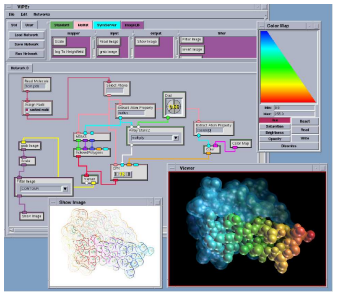
LabView, VTK, Vision, Orange, VisTrails, ...

Advantages

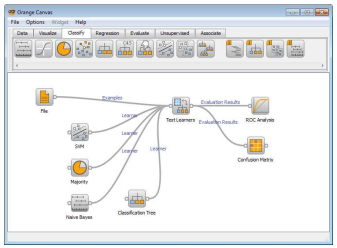
- Interactive creation and modification of flexible workflows
- Visual representation of the structure of a model
- Dynamic composition of software components

Drawbacks

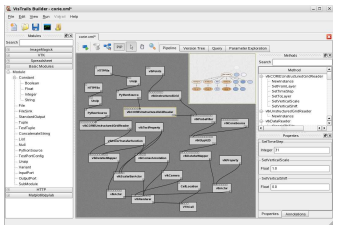
- Less expressive than textual languages (for, while)



Vision (Sanner *et al.*, 2002)

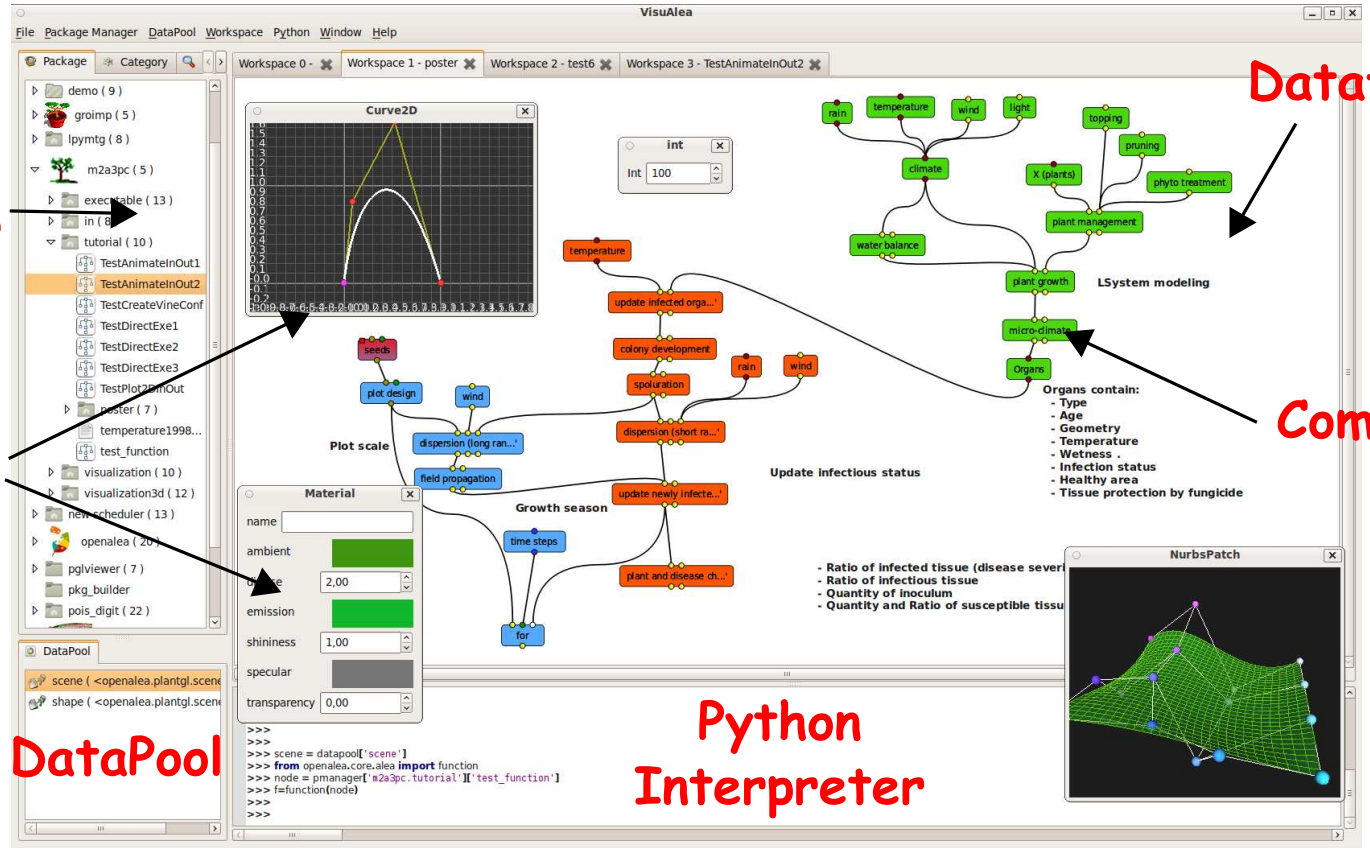


Orange (Demsar *et al.*, 2004)



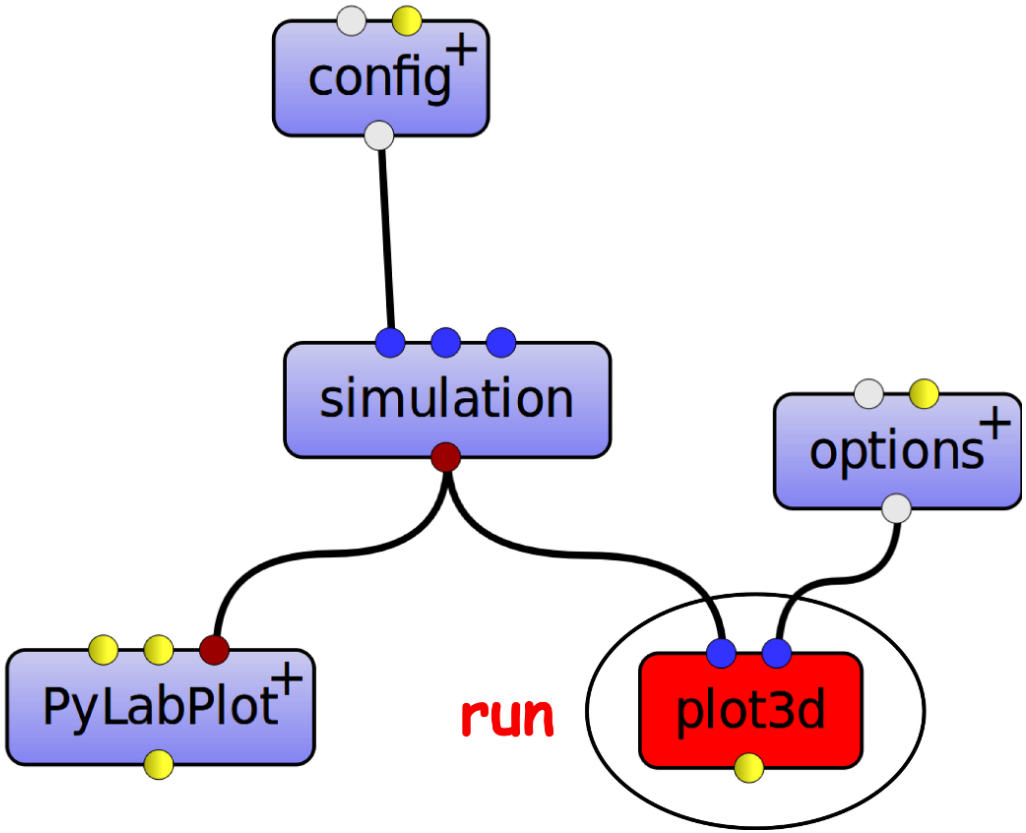
VisTrail (Freire *et al.*, 2005)

VisuAlea


Package Manager
Widgets
DataPool
Dataflow
Component
Python Interpreter
VisuAlea
File Package Manager DataPool Workspace Python Window Help
Package
Category
Workspace 0 -
Workspace 1 - poster
Workspace 2 - test6
Workspace 3 - TestAnimateInOut2
Curve2D
int
Int 100
Material
name
ambient
emission
shininess 1,00
specular
transparency 0,00
DataPool
scene (<openalea.plantgl.scene
shape (<openalea.plantgl.scene
rain
temperature
wind
light
topping
pruning
climate
X (plants)
phyto treatment
plant management
water balance
plant growth
LSystem modeling
micro-climate
Organs
Organs contain:
- Type
- Age
- Geometry
- Temperature
- Wetness .
- Infection status
- Healthy area
- Tissue protection by fungicide
seeds
plot design
wind
Plot scale
dispersion (long ran...'
field propagation
Growth season
time steps
for
update infected orga...'
colony development
sporulation
dispersion (short ra...'
update newly infecte...'
plant and disease ch...'
Update infectious status
- Ratio of infected tissue (disease severi
- Ratio of infectious tissue
- Quantity of inoculum
- Quantity and Ratio of susceptible tissu
NurbsPatch
>>>
>>>
>>> scene = datapool['scene']
>>> from openalea.core.alea import function
>>> node = pmanager['m2a3pc.tutorial']['test_function']
>>> f=function(node)
>>>
>>>

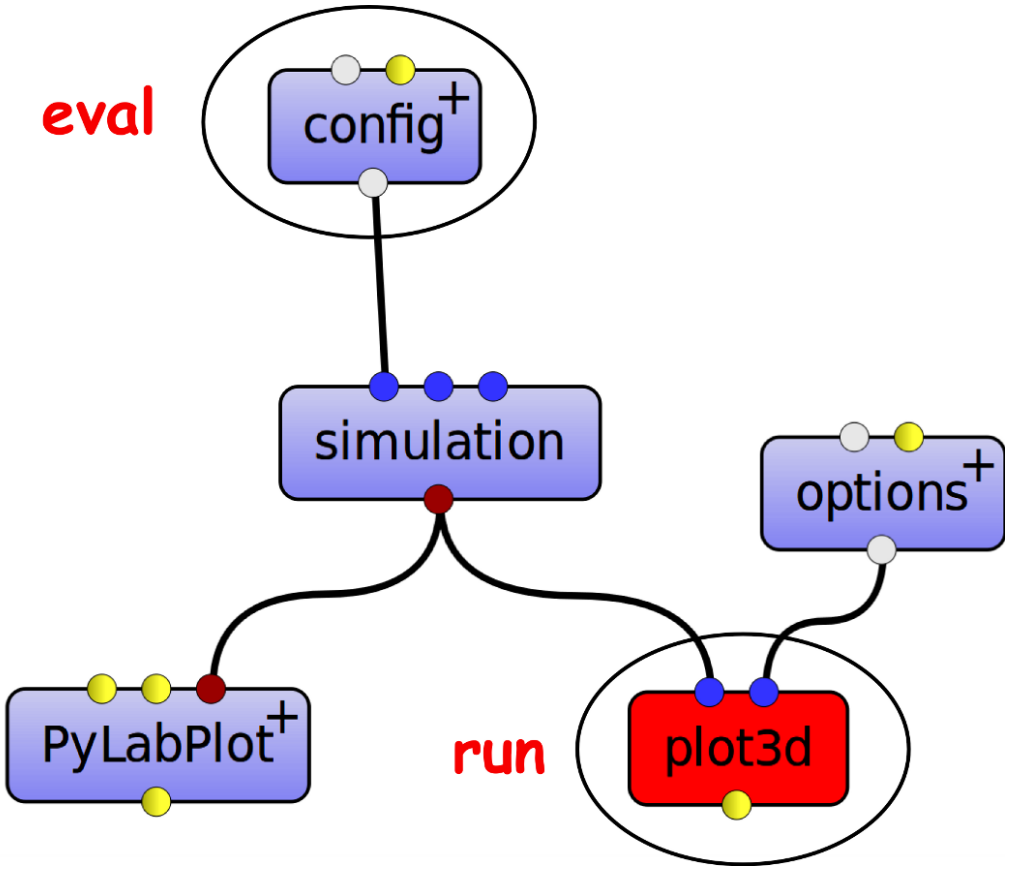
Dataflow Evaluation

Demand driven evaluation



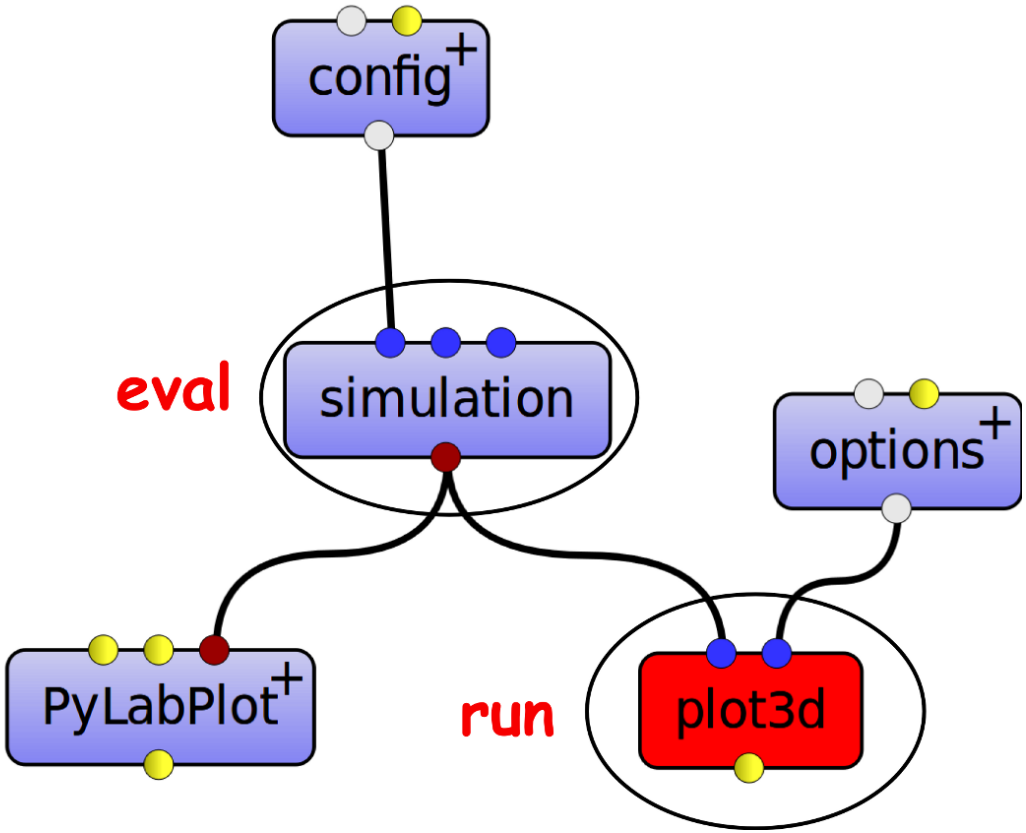
Dataflow Evaluation

Demand driven evaluation



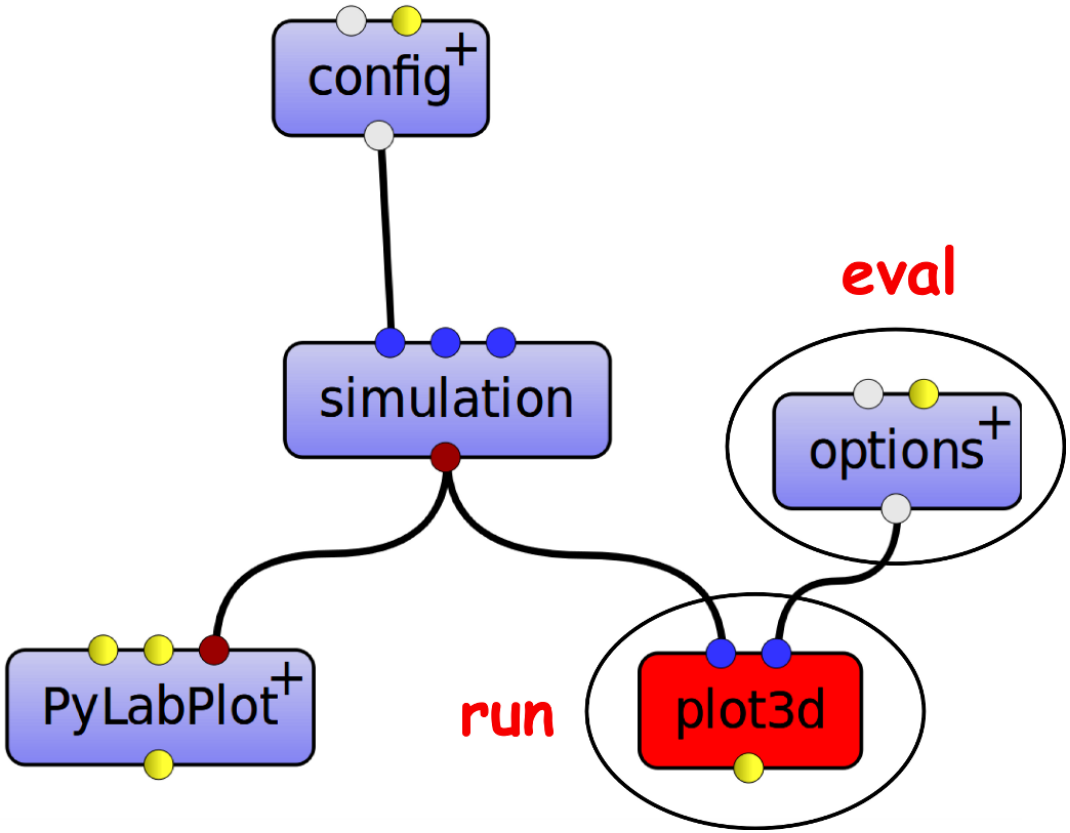
Dataflow Evaluation

Demand driven evaluation



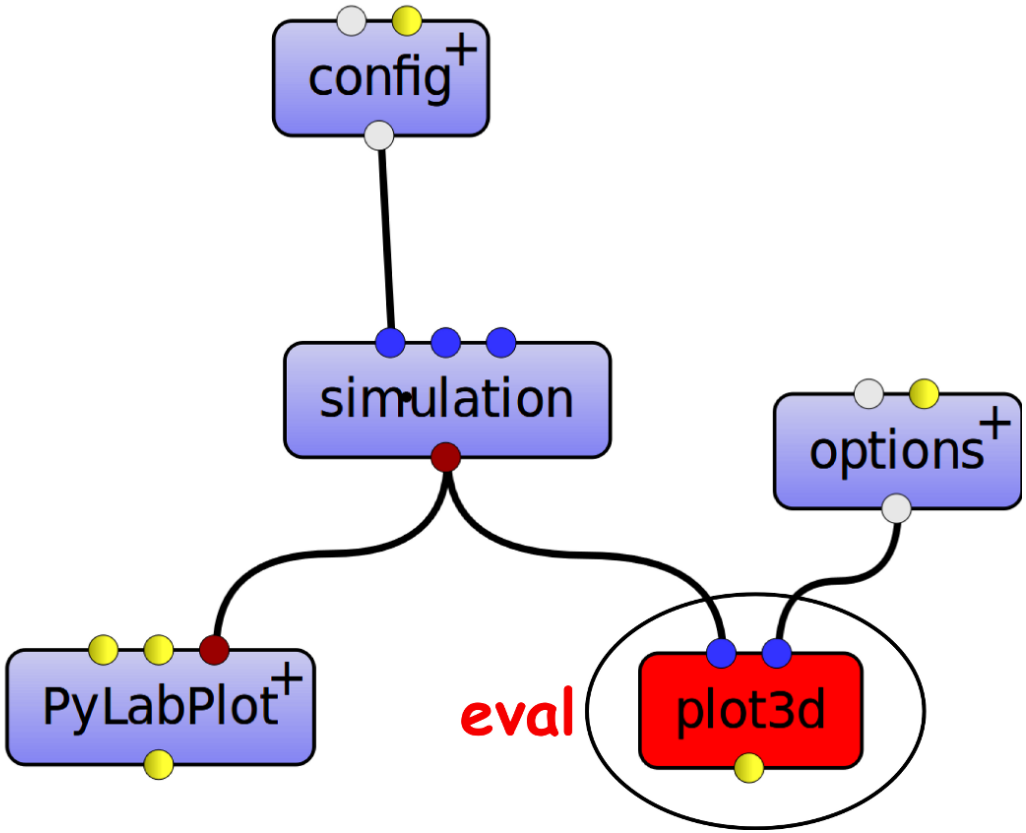
Dataflow Evaluation

Demand driven evaluation



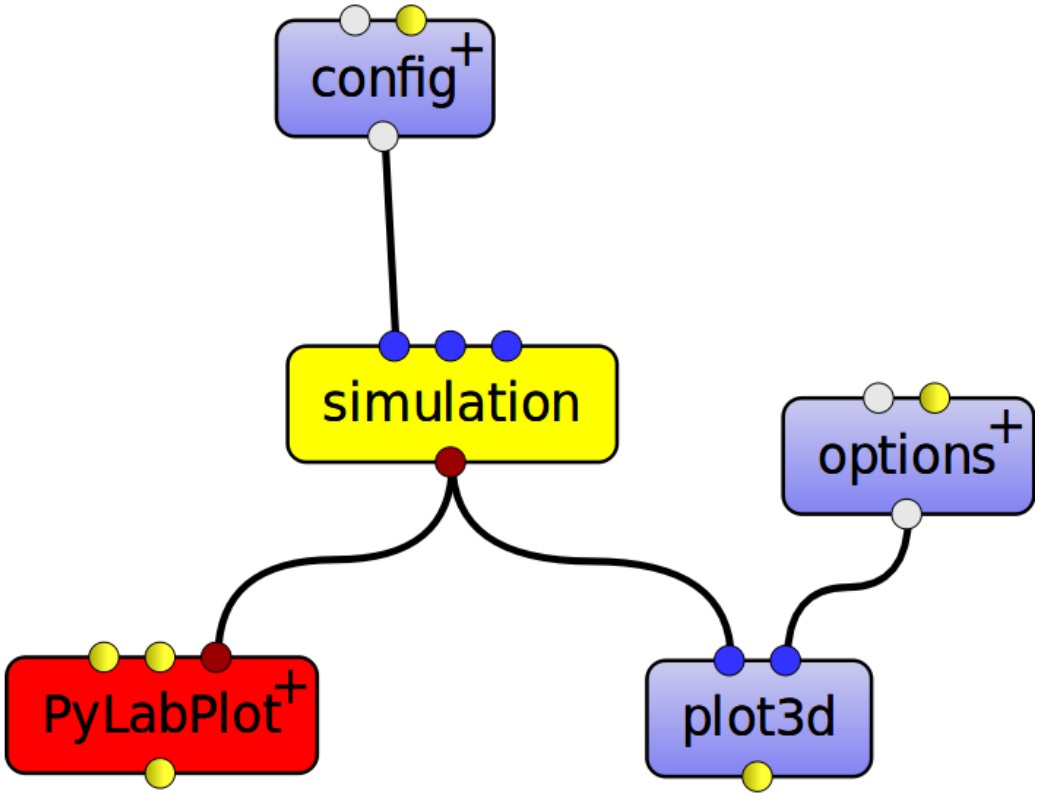
Dataflow Evaluation

Demand driven evaluation



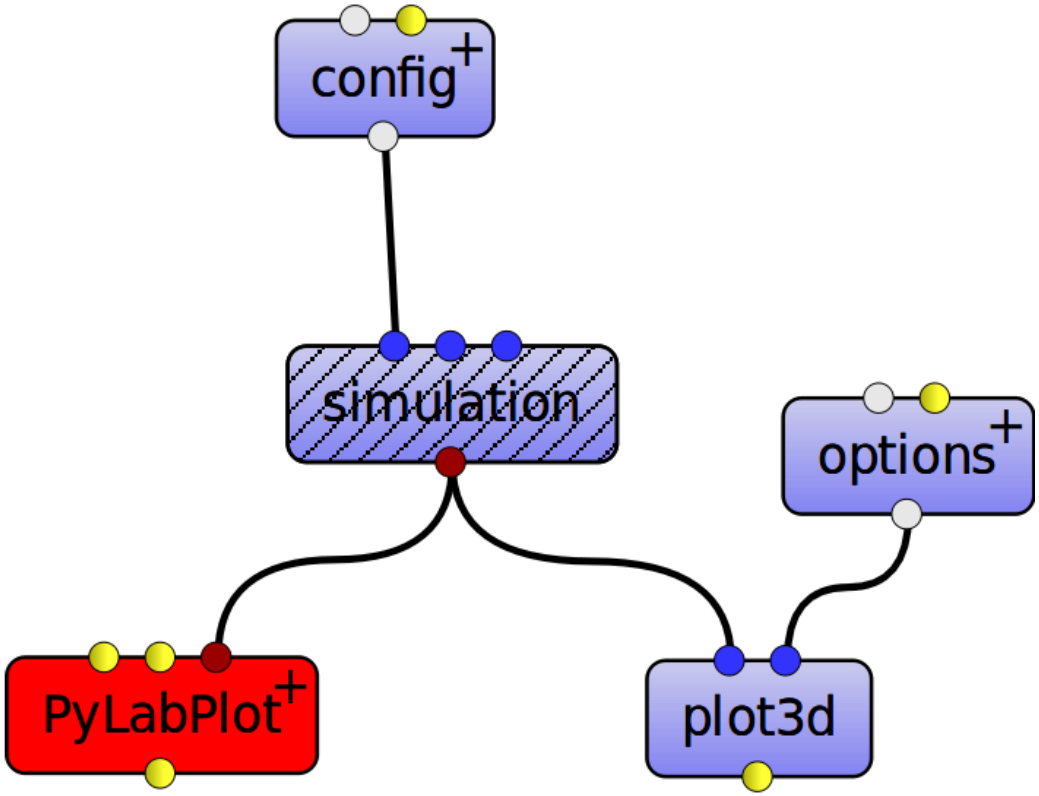
Dataflow Evaluation

Lazy node: re-evaluated only when one of its inputs has changed



Dataflow Evaluation

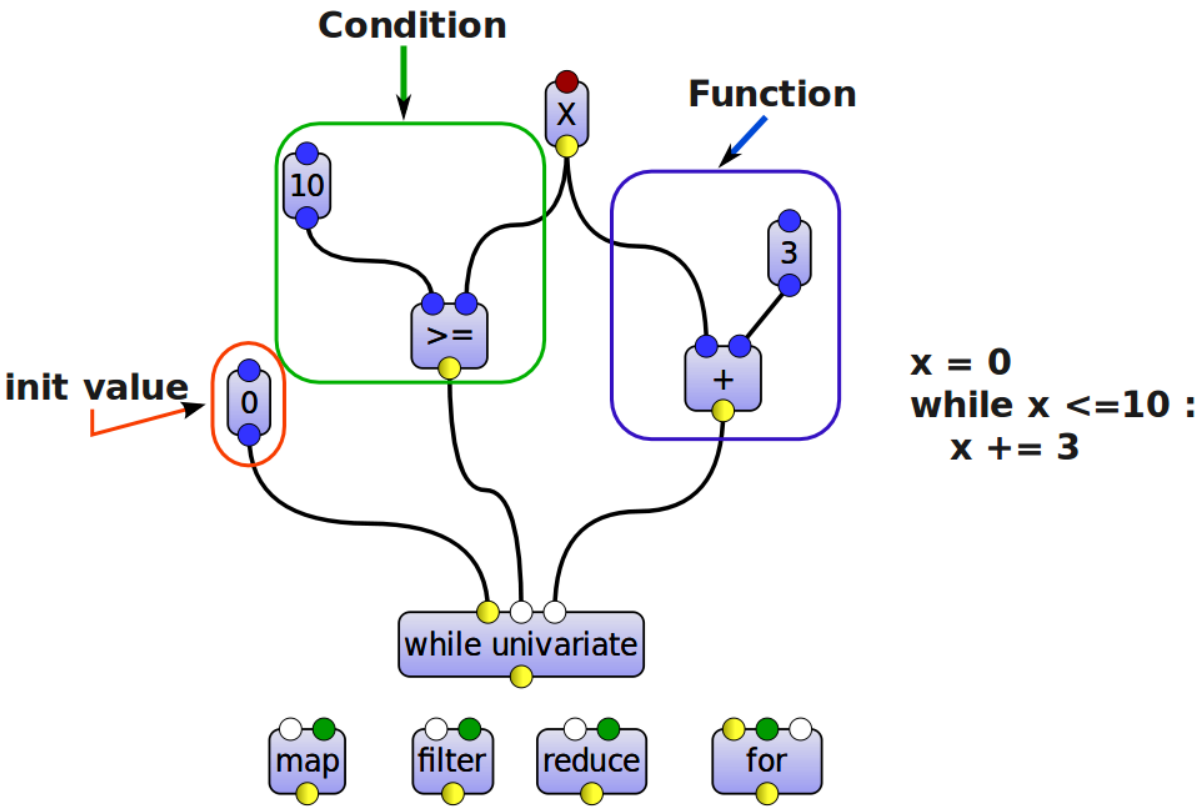
Block node: do not propagate the evaluation



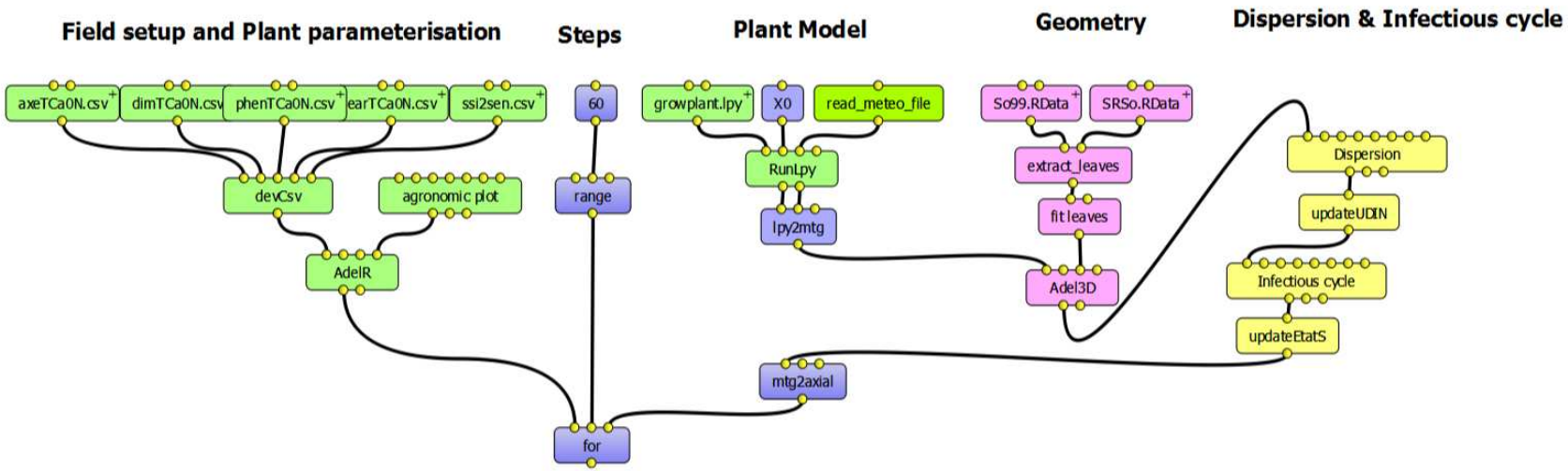
Dataflow Evaluation

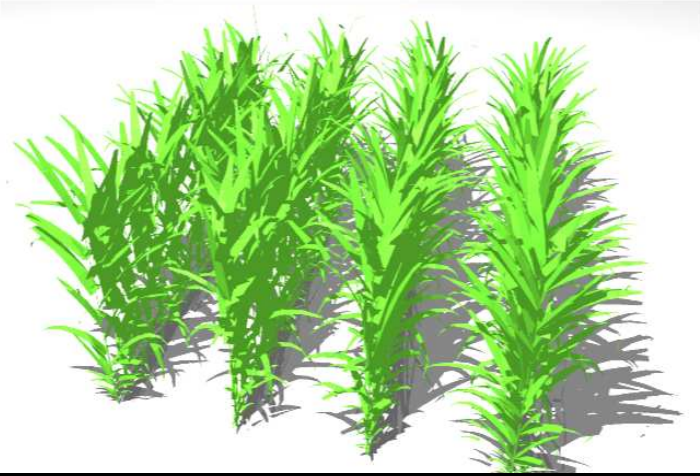
Dataflow = no side effects + no cycle.

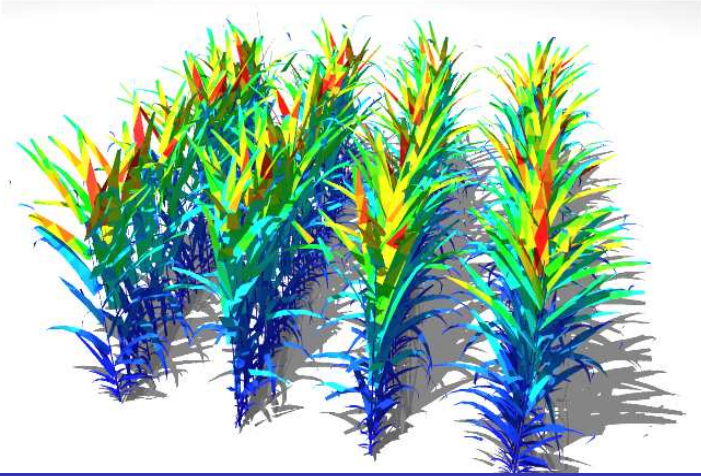
X node: transform a sub-dataflow into a **lambda** function



Example: simulation of plant/disease interaction



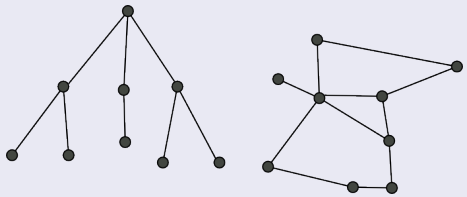




GraphEditor

Need for a **reusable python library** to **view and edit** (m)any **different graph types**, with support for **PyQt4**.

Concepts

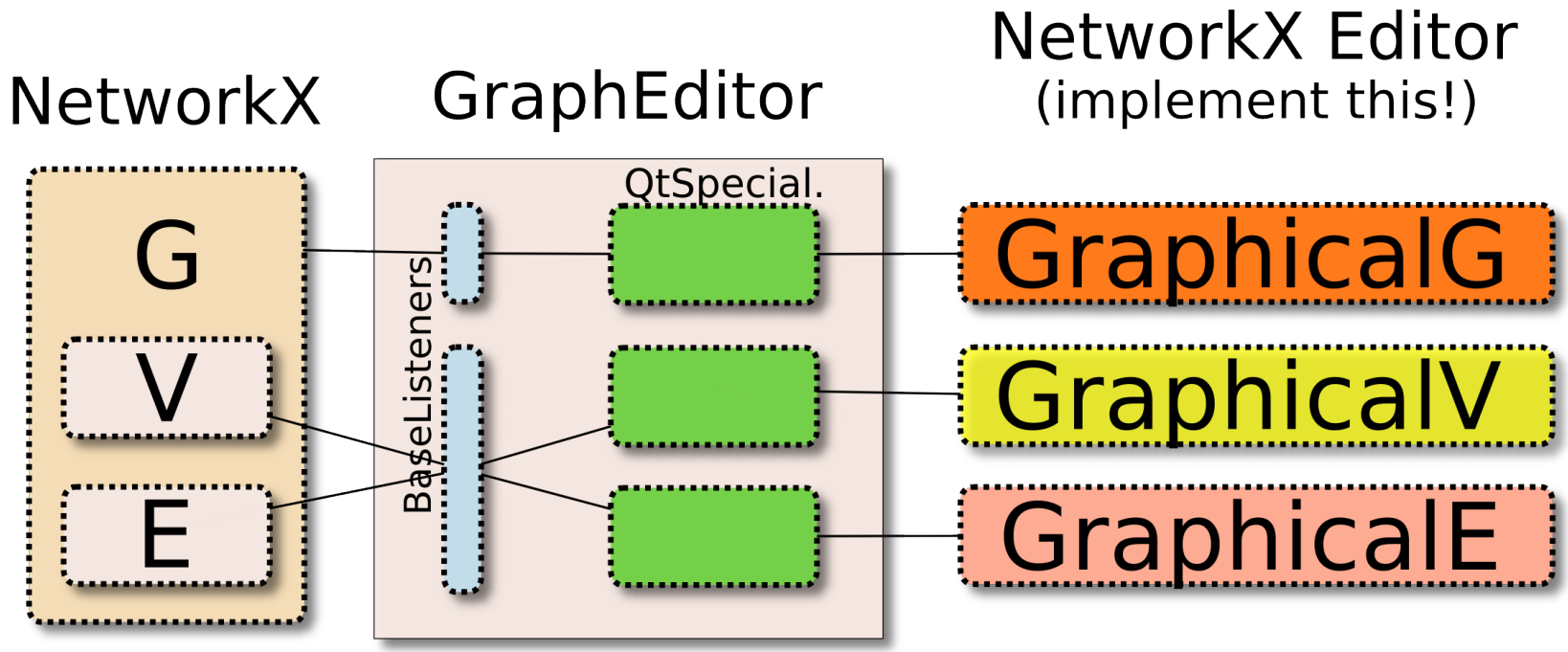


Trees, networks, dataflows (etc ...) boil down to G = { V, E } so
GraphicalG = { *GraphicalV*, *GraphicalE* }

GraphEditor

- Simplifies the implementation of custom graph editors
- Both aspect and interaction are customizable
- Has a PyQt4 implementation of the basic API

Example: Building an editor for NetworkX



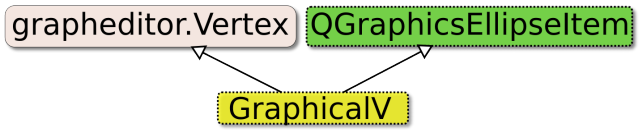
The user implements a strategy to view the data

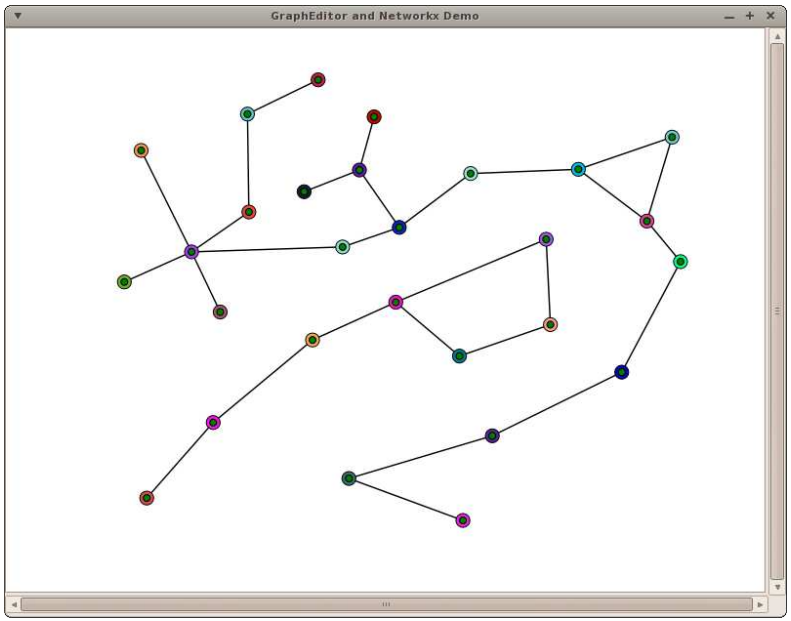
Example: Building an editor for NetworkX

Implement a simple vertex representation

```
class GraphicalVertex(Vertex, QGraphicsEllipseItem):
  def __init__(self, vertex, graph):
    QGraphicsEllipseItem.__init__(self, 0, 0,
                                  20, 20, None)
    Vertex.__init__(self, vertex, graph,
                    defaultCenterConnector=True)
    self.initialise_from_model()
```

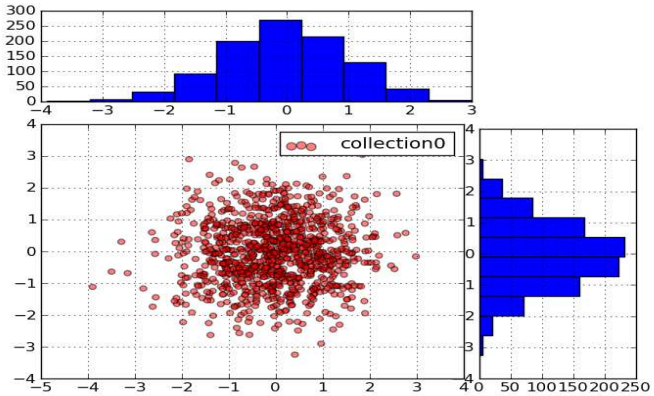
```
  def initialise_from_model(self):
    ''' Read the properties stored in the NetworkX
    graph that can be useful for the view. '''

    # Define the position of the vertex in the view
    self.setPos(self.node()['position'])
    # Define the color of the vertex in the view
    color = self.node()['color']
    self.setBrush(QBrush(color))
```



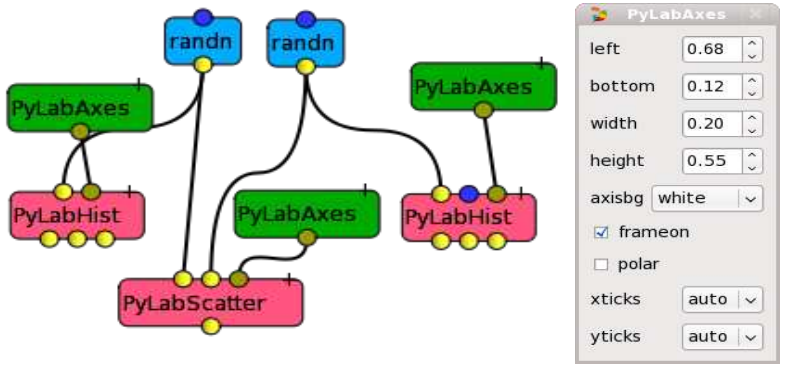


Libraries integration

- In VisuAlea, wrapping/integrating existing librairies into a GUI is made simple.
- Pylab/Matplotlib example: most of Pylab functionalties are available showing the feasability of integrating complex standard librairies into VisuAlea.



PyLab output figure from the dataflow above.



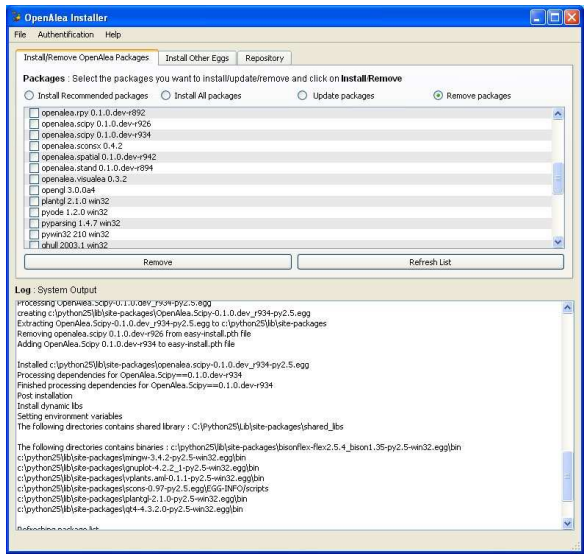
Dataflow that combines scatter and histogram nodes applied on binormal random distribution using Pylab and Numpy functionalities.

- Main advantage: existing options are now accessible as widgets.
- Numpy and Scipy components are integrated on demand.

Deployment and QA

How to distribute large number of binary packages on Mac, Linux, Windows?

- Building & Packaging
  - SCons (C/C++ building) and setuptools: creation of eggs
  - Retrieve the eggs from the web
- Graphical Installer
- Continuous integration (buildbot)
- Automated package creation:
  - SCons files, setup.py, Sphinx conf, ...



Drawbacks

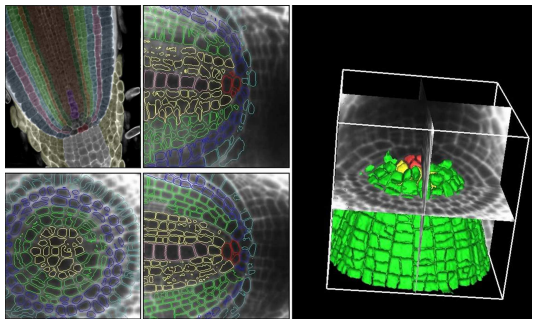
Time consuming and fragile.

Conclusions

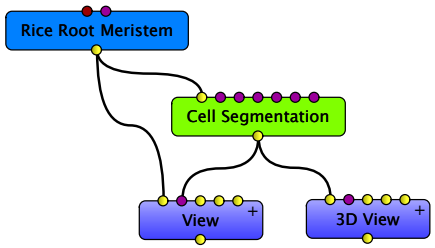
- OpenAlea provides a visual programming environment called VisuAlea
- VisuAlea allows to manage various scientific models in a GUI
  - Foster components/widgets reuse between labs
  - Ease communication
- Recent improvements:
  - Feedback loops using functional programming
  - Graph Editor
  - Many new packages from co-developers: (Biophysics models, image processing, ...)

Perspectives

- Integration of image processing algorithms and visualization tools
  - Registration
  - Fusion
  - Automated cell segmentation
  - Lineage computation
- Parallelization
- Reproductible dataflow simulation



Cells Segmentation and visualization in a rice root meristem (Fernandez *et al.*, Nature Methods, 2010)



Dataflow using a segmentation algorithm and visualization tools

Thank you!

http://openalea.gforge.inria.fr